Introduction: Celebrating the Past, Anticipating the Future

This edition of *Science and Engineering Indicators* is being released in the year 2000—the 50th anniversary of the creation of the National Science Foundation (NSF). In recognition of this event, the National Science Board (NSB) resolved to adopt a special historical theme for *Science and Engineering Indicators – 2000* considering the objectives that characterized U.S. science and engineering 50 years ago as a context for examining the current state of the Nation's science and engineering (S&E) enterprise.

The National Science Foundation Act of 1950, which President Harry S Truman signed into law on May 10 of that year, gave NSF the mandate, " . . . to promote the progress of science; to advance the national health, prosperity, and welfare; and for other purposes."[1] From its creation, the collection, analysis, and dissemination of quantitative information on the status of science and technology in the United States were an integral component of NSF's responsibilities. As the Nation moves into the 21st century, information on science, engineering, research, and education is assuming an ever more important role in our economy and society.

The National Science Board is responsible, by law, for developing on a biennial basis, a report " . . . on indicators of the state of science and engineering in the United States."[2] The *Science and Engineering Indicators* series was designed to provide a broad base of quantitative information about U.S. science, engineering, and technology for use by public and private policymakers. The chapters that follow contain analyses of key trends that illuminate the scope, quality, and vitality of research and education in the Nation and in an international context. Understanding these trends helps to prepare decisionmakers, scientists and engineers, and the public to deal with their consequences and challenges.

In addition to an historical chapter, the report presents trends in U.S. and international research and development (R&D) funds and alliances, in the S&E workforce, in science and mathematics education from the elementary level through graduate school and beyond, and in public attitudes and understanding of science and engineering. *Science and Engineering Indicators – 2000* also devotes a chapter to the significance of information technologies for science and the daily lives of our citizens in schools, the workplace, home, and community.

[1] *National Science Foundation Act of 1950*, Public Law 81-507 (Stat. 149).

[2] "The National Science Foundation Act of 1950, as amended, states that the Board is responsible for "rendering to the President for submission to Congress in each even-numbered year a report on indicators of the state of science and engineering in the United States." *NSF Statutory Authority*, Section I, Sec.4 [j][1], 6.

NSF was created near the end of a period in which the country's science and engineering resources were mobilized for World War II. What emerged in peacetime was a system designed to facilitate partnerships in support of a broader set of national science and technology (S&T) objectives. Although the specific issues evident in documents from the late 1940s differ from those that are familiar today, several current policy concerns have antecedents from that period. The chapters of *Science and Engineering Indicators – 2000* recall notable themes, but their emphasis is on the current S&T enterprise, as has been the case for all earlier editions in the *Science and Engineering Indicators* series.

Enduring Themes

A number of issues that were of concern prior to the founding of the NSF have continued to be of interest to decisionmakers. Indeed, they have been monitored in *Science and Engineering Indicators* reports over the years. Chapter 1 discusses these enduring themes in more detail. The following provides a brief summary of some of them and indicates where they are treated in the report:

- **Support and performance of R&D.** The funding and conduct of R&D has always been viewed as essential to the Nation. Funding by both the Federal and industrial sectors has grown impressively over the years and the relative importance of each has varied over the period. Striking the correct balance among defense-related and health-related R&D, and R&D in other fields has been an ongoing concern. Chapter 2 presents R&D expenditures by sector, field, and type of research in the United States and abroad. Chapters 6 and 7 concentrate on activities in the academic sector and the industrial sector, respectively.

- **Role of the Federal Government in the support of basic research.** Federal Government support of basic research has been central to the development of a thriving U.S. university system. That support continues today as an essential investment in the performance of research. New patterns of collaboration in innovation enrich the United States as the world's premier graduate research and education system. Chapter 6 provides an in-depth analysis of academic research and education, personnel, and outputs.

- **Human resources for science and engineering.** The importance of human resource development and the necessity of providing a trained S&T workforce and educated citizenry have been a consistent Federal concern. The

deficit of trained scientists and engineers resulting from World War II was critical at the time of NSF's founding. The potential contributions of foreign students were recognized even before the participation of women and U.S. minorities became a priority. The role of women, minorities, and persons with disabilities is now regarded as vital to future S&T capabilities. While chapter 3 provides an in-depth analysis of the S&E workforce by training and occupation, chapter 4 discusses the role of higher education in the education and training of scientists and engineers. Both chapters present data on domestic diversity patterns and information on the training, utilization, and mobility of foreign scientists and engineers.

- **Importance of science and mathematics education.** In the post-World War II era, it was clear that improved education at all levels from pre-college through graduate training was essential. This is equally true today. Many of the same concerns and problems endure and even though some progress has been made, more is necessary. Chapter 5 summarizes data and analysis of elementary and secondary mathematics and science, including comparisons of U.S. student performance with that of students in other countries. There is no greater challenge than renewal of a skilled workforce and of citizens able to use their knowledge of science and mathematics in their daily lives. Chapter 8 updates information on public attitudes toward science and technology and discusses what the public does and does not understand regarding several science and engineering topics and issues. It also indicates where people get their information—including from the World Wide Web.

- **R&D and innovation as a key to economic growth.** Early on, science and technology were seen as key to economic growth, competitiveness, and jobs. Other countries have expanded their technological capabilities and technical information is more easily transferred across borders. Chapter 7 offers information on industry, technology, and the global marketplace and discusses aspects of the innovation system such as venture capital, patenting activities, and global technology trade patterns and capabilities. After World War II, it was recognized that new discoveries lead to the emergence of new technologies and economic growth and vice versa. Chapter 9 examines one area of scientific advancement—information technology (IT)—developed from a confluence of different disciplines that is transforming our economy and changing the conduct of research and education.

- **International cooperation in science and technology and globalization patterns.** The importance of international S&T cooperation and competition was already recognized when NSF was created. However, the growth in collaboration and S&T capabilities globally could not be fully envisioned at the time. Each of the nine chapters in *Science and Engineers Indicators – 2000* highlights international comparisons: R&D expenditures, globalization patterns, and alliances (chapter 2); utilization of foreign S&E's, graduate training of foreign S&E students, and international patterns of S&E mobility (chapters 3 and 4); international scientific cooperation in terms of coauthorship and citation (chapter 6); interactions and trade patterns between economies in intellectual property and technology (chapter 7); international comparisons of student performance assessments in mathematics and science (chapter 5) and of public perceptions of science and technology (chapter 8). Chapter 9 discusses how information technologies make worldwide communications easier and faster, particularly the effects of personal computer penetration and Internet access in various countries on collaborative research.

Evolution of the *Science and Engineering Indicators* Reports

The form of the Board's first report, *Science Indicators – 1972*, was suggested by Roger W. Heyns, a member of the National Science Board from 1967–76, who became the chairman of its first Science Indicators Committee. He suggested that for its mandated 1973 annual submission to the President and Congress, the Board might consider preparing a report analogous to periodic reports that assessed various economic and social trends in terms of quantitative data series known as social indicators. Preparation of such a report, he further suggested, could draw on the proven capabilities of the NSF staff in gathering and analyzing quantitative data on the U.S. and international science and engineering enterprise. The National Science Board accepted Heyns' suggestion, naming its fifth report to the Congress, *Science Indicators – 1972*.[3] The positive reception accorded the first *Indicators* volume confirmed the wisdom of the statutory requirement that the Board issue these reports on a biennial basis.

On May 19, 1976, in testimony before the House of Representatives' Subcommittee on Domestic and International Scientific Planning, Heyns highlighted some of the main purposes and functions of the *Indicators* reports:[4]

- to detect and monitor significant developments and trends in the scientific enterprise, including international comparisons;
- to evaluate their implications for the present and future health of science;
- to provide the continuing and comprehensive appraisal of U.S. science;
- to establish a new mechanism for guiding the Nation's science policy;
- to encourage quantification of the common dimensions of science policy, leading to improvements in research and development policy-setting within Federal agencies and other organizations; and

[3] *Science Indicators – 1972* (NSB-73-1).

[4] *Science and Engineering Indicators - 1993, pg. xi*, Washington, DC: US Government Printing Office, 1993. (NSB 93-1).

♦ to stimulate social scientists' interest in the methodology of science indicators as well as their interest in this important area of public policy.

Over the years the Board has continued to expand and refine the *Science & Engineering Indicators* reports. The current issue, *Science & Engineering Indicators – 2000*, is the 14th in the biennial series. This important national and international data resource is part of the Board's larger responsibility in the area of national science and technology policy.

The Act further authorizes the Board to advise the President and Congress on matters of science and engineering policy (Sec. 4 [j][2]). In accordance with this broader obligation, the Board has issued a series of occasional papers commenting on selected trends in the *Indicators* report to focus attention on issues of particular current and long-term importance regarding the Nation's science and engineering enterprise.

Today, the need for quantitative data to assist in decisionmaking is even stronger than it was when the Board first began this effort. The U.S. science and technology enterprise is in transition. The Nation is changing its priorities for R&D investment and faces a number of challenges in balancing the Federal budget. And, of course, science and engineering have always had a global dimension. As globalization intensifies, *Science & Engineering Indicators – 2000* emphasizes international comparisons in the data and analyses it presents.

New Features of this Report

Science & Engineering Indicators – 2000 begins with a special historical chapter, with historical sidebars featured in many other chapters as well. The report ends with a chapter on the significance of information technologies for science and the daily lives of our citizens in schools, the workplace, home, and community. In between these chapters, the report updates the indicators on key topics and issues that have appeared in previous reports. For example, *Science & Engineering Indicators – 2000* provides new and enhanced indicators and analyses in the following areas:

♦ globalization and international comparisons—including extended coverage of emerging economies and developing countries;

♦ output indicators—including, for the first time, coverage of the publications and citation patterns of the social sciences;

♦ enhanced information on partnerships, alliances, and collaborations—particularly international S&T cooperation;

♦ public attitudes topics—including data on attitudes toward biotechnology and the public's use of information technologies;

♦ increased information on foreign scientists and engineers and international mobility patterns;

♦ discussion of school reforms, technology in schools, and distance learning in universities;

♦ age and retirement trends for scientists and engineers;

♦ developments in IT—including electronic commerce, the existence of a "digital divide," and evidence of use of the World Wide Web by governments around the world;

♦ modes of financial support and debt burden of science and engineering Ph.D.s;

♦ increased coverage of R&D in the service sector; and

♦ updated data on venture capital funds.

A Continuing Responsibility

The Strategic Plan of the National Science Board recognizes the important role of the *Science & Engineering Indicators* series and pledges to continue to develop and improve the series.[5] The plan states:

> As the Federal budget and policy processes have accentuated the demand for greater accountability and benchmarking, the data historically available through *S&EI* have become increasingly valuable for analyzing key trends that illuminate the scope, quality, and vitality of research and education. Thus, *S&EI* serves two critical purposes: first, as the report of record on the health of the enterprise; and second, as the basis for further analysis by all users generally and by the Board in particular. To insure that S&EI effectively supports these goals, the National Science Board reviews the report's effectiveness with each biennial cycle. The policy and planning demands of the coming years make this task more compelling than ever.

To position *Science & Engineering Indicators* for the 21st century, the Board committed to conducting a comprehensive review of *Science & Engineering Indicators*, including the utility, timeliness, and accessibility of the data for users; and reviewing the effectiveness of the report as a basis for decision making on major policy issues related to science and engineering.

Each of the chapters of *Science & Engineering Indicators – 2000* received extensive external technical peer review. The Board believes that this process has greatly improved the report, and wishes to thank those reviewers who contributed their time and efforts. Their names are listed in "Contributors and Reviewers."

To make the data and analyses more accessible, the report is available in hardcopy, on CD-ROM, and on the World Wide Web (http://www.nsf.gov/sbe/srs/stats.htm). This website also contains new data on the reported indicators, as they become available.

An innovation with this edition is dividing the report into two volumes. Volume 1 contains the text and the index, and Volume 2 contains the appendix tables. This year's edition takes advantage of widespread access to computer CD-ROM readers by including Volumes 1 and 2 in PDF format and the

[5]National Science Board, *National Science Board Strategic Plan*, November 19, 1998, NSB 98-215, 18-19.

appendix tables in Volume 2 also in Excel format on the CD attached to the back cover of Volume 1. For readers who might prefer to access the appendix tables in printed form, Volume 2 is available on request from NSF (see the back inside cover for ordering information).

Other innovations in the form, content, and accessibility of *Science and Engineering Indicators* will be examined in the coming decade. The Board welcomes the opportunity and challenge to develop new and refined indicators that capture and document changes in the national and global science and engineering enterprise.

In the last *Science and Engineering Indicators* report of the century, the Board would like to recognize the partnership it has had not only with the Executive Branch but also with the Congress. The science and technology policy to be forged in the next millennium will be better informed by data. The National Science Board hopes that members of the Congress will find *Science & Engineering Indicators – 2000* of assistance as they grapple with the many issues related to science, technology, and the knowledge-based economies of the 21st Century.